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Evolution of geological processes on terrestrial planets and their impact on the environment

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It is known that the Earth's ecological systems in the Middle Paleoproterozoic were subjected to fundamental change. Though life has been already existed in the Paleoarchean (Schidlowski, 1988), the multicellular organisms appeared only in the middle Paleoproterozoic (∼2.0 Ga) (Sayutina, Vil'mova, 1990). This was preceded a cardinal change in the type of magmatism, occurred in period from 2.35 to 2.0 Ga, when high-Mg magmatism of the early Precambrian, derived from depleted mantle, gave place to the geochemical-enriched Fe-Ti picrites and basalts, similar to the Phanerozoic within-plate magmas. New type of magmas was characterized by elevated and high contents of Fe, Ti, Cu, P, Mn, alkalis, LREE, and other incompatible elements (Zr, Ba, Sr, U, Th, F, etc.). At the boundary of 2 Ga, the plume tectonics was replaced by plate tectonics, which led to gradual replacement of ancient sialic continental crust by secondary oceanic (mafic) crust.

That time was marked by the appearance of first fungi (Belova et al., 2006). These organisms not only caused the decomposition of organic matter, but served as active agents of biological weathering, playing an important role in biogeochemical cycle of biophile elements, including aforementioned metals and other elements (primarily, Fe, Cu, Zn, Co, Ni, and P), and correspondingly their supply in the World Ocean. A large-scale influx of alkalis in the World Ocean presumably neutralized its water, making it more suitable for the life, while input of Fe-group metals, P, and other trace elements, which are required for metabolism and fermentation, rapidly expanded the possibility for the development of biosphere. The manifestation of this geochemically enriched magmatism is correlated with the first finds of eucaryotic heterotrophic organisms at ∼ 2 Ga (Rozanov, 2008), and with rapid evolution of organic life, especially photosynthesizing cyanobacteria. The vital activity of the new organisms significantly increased the oxygen content in atmosphere, which was marked by the formation of cupriferous red beds at all Precambrian shields, generation of the first hydrocarbon deposits (shungites, Karelian craton), and phosphorites with age of 2.06 Ga on the Indian and Kola cratons (Melezhik et al., 2005).

Thus, a fundamental change in tectonomagmatic activity acted as the trigger for environmental changes and biospheric evolution, supplying a qualitatively new material on the Earth's surface. Data available on Venus and Mars suggest that their tectonomagmatic evolution also followed similar scenario (Sharkov, Bogatikov, 2009). The presence of drainage systems on Mars and valleys on Venus assumes the existence of liquid water at the early stages of their development. Like on the Earth, red beds and global glacials appeared on the Mars at the middle stage of it's evolution, and may be at this period ancient microorganisms existed on Mars (McKay et al., 1996). Powerful eruptions of gigantic volcanoes of Tharsis and Elysium, probably, led to fall of temperature and disappearance of liquid water on Mars. In contrast to Mars, on Venus appeared speeded up greenhouse effect, which also led to dry and very hot surface.